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ROCKCASTLE MANUFACTURING
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I. SUMMARY

On July 10, 1987, the National Institute for Occupational Safety and Health (NIOSH) received a request for a health hazard evaluation from employees at Rockcastle Manufacturing, Mount Vernon, Kentucky. NIOSH was asked to evaluate complaints of headaches, burning eyes, nausea, vomiting, fainting, and adverse reproductive effects among employees at this facility, which fabricates men's uniform work pants.

On September 8-9, 1987, NIOSH investigators conducted a combined environmental and medical evaluation. Personal breathing zone and general area air samples for formaldehyde, organic vapors, and particulates were collected, patches of the resin-treated fabrics used in garment manufacture were obtained for determination of formaldehyde release, and confidential interviews were held with employees.

Because a number of ventilation and work practice changes were made following the initial site visit, a follow-up visit was made on January 12-14, 1988. Exposure monitoring for formaldehyde and particulates was performed, and a questionnaire was administered to employees to obtain information on various symptoms, including musculoskeletal problems, and, for women, their reproductive history. The questionnaire was sent to former employees who worked any time after September 1, 1984.

Formaldehyde air sampling results from the initial survey ranged from 0.14 ppm to 0.46 ppm in five personal breathing zone (PBZ) air samples, and from 0.32 ppm to 0.70 ppm in 13 area air samples obtained throughout the plant. On the follow-up survey, formaldehyde exposures were lower, with PBZ concentrations ranging from 0.19 ppm to 0.21 ppm, and from 0.18 ppm to 0.22 ppm in area air samples obtained in production departments. The formaldehyde data also showed less variation between departments and job classifications. All formaldehyde results were below the OSHA and ACGIH evaluation exposure limits of 1 ppm, as an 8-hour TWA. NIOSH, however, considers formaldehyde a potential carcinogen, and recommends that formaldehyde exposures be reduced to the lowest feasible level.

Formaldehyde release from 8 fabric samples ranged from 163 micrograms of formaldehyde per gram of fabric (ug/gm) to 1430 ug/gm. Two samples that were cured prior to analysis showed reductions in formaldehyde release of 42.5% and 73.5%.

Of the 4 PBZ organic vapor air samples collected on charcoal tubes, only 1,1,1-trichloroethane was detected, with all values below 0.3 ppm. The current OSHA PEL for 1,1,1-trichloroethane is

350 ppm, as an 8-hour TWA. Total particulate concentrations in 4 PBZ air samples ranged from 0.17 mg/m^3 to 2.12 mg/m^3, and from 0.02 mg/m^3 to 0.42 mg/m^3 in 5 area air samples obtained at several locations throughout the plant. All results were below the OSHA and ACGIH guidelines for nuisance particulates, 15 mg/m^3 and 10 mg/m^3, respectively. Because these particulates may contain low levels of formaldehyde, the commonly used nuisance dust criteria may not be appropriate.

The response rate for the questionnaire survey was 98% among current employees, but only 18% among former employees. The questionnaire data showed that there was a statistically significant elevated rate of birth defects, stillbirths, and premature births in women who were pregnant while working at Rockcastle Manufacturing, as compared with women who were pregnant while working elsewhere, or with women who were not working outside the home. A concentration of these adverse outcomes occurred in 1986. There was no significant difference in work areas between those who had adverse pregnancy outcomes and those who did not.

The most frequently reported non-musculoskeletal symptoms among current employees were irritation of the eyes (27%), nose (23%), and headaches (22%). Musculoskeletal complaints were even more prevalent, with 38% of the respondents indicating they had frequent shoulder pain, 35% neck pain, and 35% lower back pain.

The environmental data collected indicate that employees are exposed to low levels of formaldehyde. The reported symptoms of eye, respiratory, and skin irritation, and headaches, are compatible with these exposures. Although a statistically significant elevated rate of adverse reproductive outcomes was documented, these findings could not be associated with current workplace exposures. Since formaldehyde is a potential carcinogen and has irritant properties at low levels, recommendations to further reduce exposures to the lowest feasible level are made in Section VIII of this report, along with recommendations for evaluating potential ergonomic hazards and for monitoring future reproductive outcomes of employees.

KEYWORDS: SIC 2328 (Men's, Youth's, and Boy's Furnishings, Work Clothing, and Allied Garments), formaldehyde, irritation, reproductive effects, post-cure fabrics.

II. INTRODUCTION

On July 10, 1987, the National Institute for Occupational Safety and Health (NIOSH) received a confidential request for a Health Hazard Evaluation from an authorized employee representative at Rockcastle Manufacturing, Mount Vernon, Kentucky. The request concerned complaints of headaches, burning eyes, nausea, vomiting, fainting, and adverse reproductive effects.

On September 8-9, 1987, an initial site visit was conducted to evaluate employee exposures to formaldehyde, organic contaminants, and particulates, and to investigate adverse health effects reported among the labor force. Preliminary recommendations regarding local exhaust ventilation, preventive maintenance, and work practices were made in a letter to Rockcastle dated September 22, 1987. Because a number of ventilation and work practice changes were made subsequent to this visit, a follow-up environmental survey was conducted on January 12-14, 1988. A health questionnaire was administered during the follow-up investigation to obtain information on work history, medical history, and symptoms experienced by employees. An identical questionnaire was mailed to former Rockcastle Manufacturing employees, and current employees who had been absent the day the questionnaire was administered.

III. BACKGROUND

Rockcastle Manufacturing is a cut-and-sew plant which fabricates men's uniform work pants. At the time of this evaluation, there were approximately 190 production employees at this facility, the majority of which (around 85%) operated sewing machines. The remaining individuals worked as press operators, oven operators, cutters, spreaders, glue sprayers, bundlers, and maintenance workers.

Cellulose-containing fabrics having a 65% polyester/35% cotton blend are used to fabricate the work pants. These fabrics are obtained from a textile finishing company, where they are impregnated with a dimethloldihydroxyethyleneurea (DMDHEU)-based resin system. This resin treatment imparts durable press properties, dimensional stability, and other important properties to cellulosic textiles (e.g. cotton, rayon and blends).[1] The manufacturing process used at this plant is considered a post-cure process, which refers to the fact that the resin is "cured" or chemically bonded to the fabric after the garment has been fabricated. Formaldehyde release from uncurred DMDHEU resin-treated fabric is thought to result from surface desorption of noncovalently bonded (or "free") formaldehyde, as well as from the hydrolysis of the formaldehyde-cellulose hemiacetal bonds.[2] The resin formulation has reportedly changed over the years, in an effort to reduce formaldehyde emission from the treated fabrics.

The manufacturing facility is located in a warehouse of sheet metal construction, having approximately 12,000 square feet of open space. Rolls of fabric are stored in the fabric storage area until needed, generally less than 90 days from receipt. The fabric is unrolled on a table in the spreading area, forming many layers of fabric. Pattern pieces are cut from the layers, using scissors or precut dies, and sorted by type. Fabric bundles are then taken to the glue room where the edges are sprayed with an aqueous acrylic emulsion, to prevent ravelling. This operation is performed in a spray booth, in a room adjacent to the sewing area. The fabric bundles are then distributed to the appropriate workstations (areas 1-4), where they are sewn and assembled into pants. Conventional sewing machines are used along with a few automated machines for specialized operations such as belt loops. After inspection, the garments

are pressed, to form creases, and are then heated in a 325°F oven for a period of approximately 15 to 20 minutes, to impart the post-cure. The finished garments are then moved to the packaging area, where they are folded, boxed, and labeled.

During this evaluation, the use of other chemical agents was limited to a perchloroethylene spray used as a spotting agent for soiled garments; a silicone spray, containing petroleum distillates, used as a machine lubricant; and a 1,1,1-trichloroethane solvent and degreasing spray.

The plant ventilation consists of 3 recirculating air handling units having both heating and cooling capacity, and a few exhaust fans located in the fabric storage area and by the curing ovens. Local exhaust ventilation had been installed above the two curing ovens a few years prior to this survey. Pedestal fans and open doors are also used as supplemental ventilation, primarily during the summer months.

As previously noted, several ventilation and workpractice changes were made after the initial NIOSH site visit. These changes included the following: (1) installation of exhaust ventilation above the steam press tables, (2) installation of canopy hoods above the three fly press stations, (3) increasing the amount of outside air supplied to the plant by increasing the opening of the air supply louvres on the three air handling units, (4) installation of a ceiling exhaust system above the sewing area, with a 10,000 cubic feet per minute design specification, (5) installation of a receiving hood in the area where spot cleaning of soiled garments is performed, and (6) replacing, for the most part, the practice of blowing lint from workstations with compressed air (and subsequent dry sweeping of the floors) with vacuuming, which was performed on breaks and at the end of the workshift. In addition, the perchloroethylene spray used for cleaning soiled garments was replaced with a 1,1,1-trichloroethane spray.

IV. METHODS

A. Environmental Evaluation

Initial Survey

On September 9, 1987, exposure monitoring for formaldehyde was performed. Five full-shift personal breathing zone air samples for formaldehyde were collected from the two oven operators, a steam press operator, a fly press operator, and the glue sprayer. Samples were collected using Chromosorb-102 solid sorbent tubes impregnated with 2-(benzylamino)ethanol and personal sampling pumps calibrated at 50 milliliters per minute (ml/min). Samples were analyzed by gas chromatography (GC) in accordance with NIOSH Method 2502.[3] Fourteen area air samples for formaldehyde were collected at several locations throughout the plant, including the areas near the presses, curing ovens, glue room, fabric storage area, and sewing area. Air samples collected in the press and sewing areas were obtained within two feet of the operation and at breathing zone height, in an effort to obtain samples representative of employee exposures. Area air samples were also obtained in the conference room for comparison. Two short-term, 15-minute duration air samples were collected for formaldehyde near the curing ovens following the removal of a rack of pants from the oven. All area air samples were collected and analyzed according to NIOSH Method 3500.[3] This method utilizes a 1% sodium bisulfite solution as the absorbing media. Sampling was conducted over the entire workshift using calibrated, personal sampling pumps operating at flowrates of 0.5 liters per minute (Lpm).

Ten bulk fabric samples were collected for latent formaldehyde analysis. Patches of fabric of varying colors were obtained from the fabric storage area, along with samples of the navy fabric which was being used during this survey. To compare latent formaldehyde levels on these fabrics, additional fabric samples were collected before and after they were cured. Individual fabric samples were stored in sealed, polyethylene bags until analyzed. Samples were analyzed for latent formaldehyde using a method developed by Burlington Industries.[4] This colorimetric method is based on the American Association of Textile Chemists and Colorists' (AATCC) sealed jar method, Test Method 112-1984, and was originally developed to assess formaldehyde release under worst-case storage conditions.[5] The method involves a vapor extraction procedure to measure formaldehyde release from a weighed patch of fabric which has been suspended over water, in a sealed jar, and heated at 50°C for 20 hours. The conditions of the test are such that both free formaldehyde and formaldehyde from hydrolysis are measured.

A bulk sample of the aqueous acrylic emulsion used to prevent ravelling of fabric edges was analyzed by infrared spectroscopy. Water was evaporated from the sample, leaving a film of the polymer. The polymer was then dissolved in acetone, and a thin film was cast on a salt plate. An infrared spectrum was then obtained of the polymer film for further identification of the components.

Eight air samples were collected for organic vapor analysis using a charcoal tube sampling technique. Area air samples were obtained in the glue room and in the oven area. Personal breathing zone air samples were obtained on individuals working in these areas, as well as by the presses. One of the air samples was collected in the headspace of the glue container to identify volatile components of this product. Representative samples were analyzed using a gas chromatograph equipped with a mass selective detector (GC/MSD) for peak identification. The remaining samples were analyzed for epichlorohydrin and acrylates (components of the glue), as well as contaminants identified in the GC/MSD analyses.

Four personal breathing zone (PBZ) and one area air sample were collected for total particulates (dust and lint) using 5-micron (um) pore-size polyvinyl chloride (PVC) filters and calibrated, battery-operated sampling pumps operating at flowrates of 1.5 Lpm. Jobs which appeared to have the greatest potential for dust exposure were selected, including maintenance, turn and ticket, spreading, and cutting. Samples were collected and analyzed in accordance with NIOSH Method 0500.[3]

To address a concern regarding heat exposure, temperature and relative humidity data were collected at several locations within the plant using a battery-operated psychrometer.

Follow-up Survey

The follow-up survey was conducted on January 12-14, 1988. Ten sets of air samples for formaldehyde were collected over the entire workshift, including three personal breathing zone and seven general area air samples. Samples were collected in many of the same areas or jobs as on the initial survey, for comparison. Side-by-side samples were collected using three different formaldehyde sampling techniques: the liquid impinger method (NIOSH Method 3500), the solid sorbent tube method (NIOSH Method 2502), and a passive diffusion method utilizing Bacharach AirScan* Formaldehyde Exposure Monitors. The purpose for matching the passive monitors with the impinger and sorbent tube samples was to observe the performance of

the monitors in the field, by comparing the results with those from established air sampling methods for formaldehyde. Flowrates of 0.5 Lpm and 0.08 Lpm were used to collect the impinger and sorbent tube samples, respectively.

Area air samples were collected for analysis of total particulates in sewing areas 1-4. Samples were collected by drawing air through pre-weighed PVC filters, using calibrated air sampling pumps operating at flowrates of approximately 2 Lpm. Sampling and analysis were performed in accordance with NIOSH Method 0500.[3]

Temperature and relative humidity measurements were again made throughout the day at several work stations, using a battery-operated psychrometer.

B. Medical Evaluation

Initial Survey

On September 8, 1987 an initial medical evaluation was made at Rockcastle. This medical investigation consisted of non-random interviewing of employees, review of OSHA 200 logs, and informal interviews with management. The purpose of the interviews was to obtain information on past and current chemical and physical agents in the work environment and identify the adverse health effects of primary concern to the labor force.

Forty-two employees were privately interviewed, including 36 hourly employees and 6 supervisors (35 women and 7 men). Information was obtained on each individual's length of employment at Rockcastle Manufacturing, work habits, location within the plant, and presence or absence of occupationally related adverse health effects. Health effects were not categorized as potentially occupational unless the employee identified them as occurring exclusively or predominantly at work, or specified plausible and specific work conditions which related the symptom(s) to work. To aid in case-finding, those interviewed were asked to identify fellow employees whom they thought might have similar health complaints.

Selection for interview was not random; therefore, the following interview findings were used not to assess overall prevalence of symptoms but to suggest areas which should be studied more comprehensively through a formal questionnaire. Forty-one of the 42 employees interviewed complained of burning eyes while at work. Fifty-six percent of these employees felt the burning occurred on a daily or regular basis, with 12% stating symptoms were worse in the morning when they first arrived, and 12% stating that the burning had lessened in the last month. Forty percent of persons interviewed complained of a burning nose, and 33% of a sore throat. Twenty-six percent complained of occasional or frequent nausea and/or vomiting at work; 43% stated either that they have headaches only at work, or that their headaches are more frequent and/or severe at work compared to when they occur away from work. Almost 30% of those interviewed attribute feeling lightheaded or fainting at work to workplace conditions. In addition, a number of workers volunteered other health effects that they believe to be work-related, including musculoskeletal injuries and complaints, rashes, and heat exhaustion. Three women reported having had an abnormal screening test for cervical cancer with subsequent medical therapy in the past year.

There were several patterns of complaints. As previously mentioned, complaints of burning eyes were more prevalent in the early morning, on hot or humid days, and when it rained. Complaints of burning eyes were less prevalent in the preceding month, which some workers attributed to the recent increase in use of fans and open doors for ventilation. The workers who reported rashes believed that the absence or presence of rash varied with the color of fabric in use.

Eight women interviewed reported adverse reproductive effects. In addition, numerous Rockcastle employees stated that they perceived a high rate of miscarriage among co-workers. Although some employees believed the excess of miscarriages began about one year after the plant opened, the majority believed the excess occurred primarily during the preceding two years. Concern was also expressed that the rate of birth defects among children of workers may also have been elevated.

Follow-up Survey

Based on the problems expressed during the non-random initial interviews, a questionnaire was designed to determine the rate of miscarriages, birth defects, and premature births, as well as the prevalence of musculoskeletal and other health complaints. This questionnaire was distributed to all employees during a follow-up visit on January 13, 1987. An identical questionnaire, as well as one follow-up reminder letter, were sent to all former employees who worked any time after September 1, 1984.

V. EVALUATION CRITERIA

A. Environmental Evaluation

As a guide to the evaluation of the hazards posed by work place exposures, NIOSH field staff employ environmental evaluation criteria for the assessment of a number of chemical and physical agents. These criteria are intended to suggest levels of exposure to which most workers may be exposed up to 10 hours per day, 40 hours per week for a working lifetime without experiencing adverse health effects. It is, however, important to note that not all workers will be protected from adverse health effects if their exposures are maintained below these levels. A small percentage may experience adverse health effects because of individual susceptibility, a pre-existing medical condition, and/or a hypersensitivity (allergy). In addition, some hazardous substances may act in combination with other work place exposures, the general environment, or with medications or personal habits of the worker to produce health effects even if the occupational exposures are controlled to the level set by the evaluation criterion. These combined effects are not often considered by the evaluation criteria. Also, some substances are absorbed by direct contact with the skin and mucous membranes, and thus potentially increase the overall exposure. Finally, evaluation criteria may change over the years as new information on the toxic effects of an agent become available.

The primary sources of environmental evaluation criteria for the work place are: 1) NIOSH Criteria Documents and Recommended Exposure Limits (RELs), 2) the American Conference of Governmental Industrial Hygienists' (ACGIH) Threshold Limit Values (TLVs), and 3) the U.S. Department of Labor (OSHA) Permissible Exposure Limits (PELs). Often, the NIOSH recommendations and ACGIH TLVs are lower than the corresponding OSHA PELs. The NIOSH RELs and ACGIH TLVs are usually based

on more recent information than are the OSHA standards. The OSHA PELs may also be required to take into account the feasibility of controlling exposures in various industries where the agents are used; the NIOSH-recommended exposure limits, by contrast, are based primarily on concerns relating to the prevention of occupational disease. In evaluating the exposure levels and the recommendations for reducing these levels found in this report, it should be noted that industry is legally required to meet those levels specified by an OSHA PEL.

A time-weighted average (TWA) exposure refers to the average airborne concentration of a substance during a normal 8- to 10-hour workday. Some substances have recommended short-term exposure limits or ceiling values which are intended to supplement the TWA where there are recognized toxic effects from high, short-term exposures.

B. Formaldehyde

Formaldehyde is a colorless gas with a strong, pungent odor detectable at low concentrations. It is commonly utilized as formalin, an aqueous solution containing 37-50% formaldehyde by weight.[6] It is widely used in the production of resins, in the manufacture of many other compounds, as a preservative, as a sterilizing agent, and as an embalming fluid.[7]

Exposure to formaldehyde can occur through inhalation or skin absorption.[8] The primary non-carcinogenic effects associated with formaldehyde exposure are irritation of the mucous membranes of the eyes and respiratory tract, and allergic sensitization of the skin. The first signs or symptoms noticed on exposure to formaldehyde, at concentrations ranging from 0.1 to 5 ppm, are burning of the eyes, tearing, and general irritation of the upper respiratory passages. There does, however, appear to be a great deal of variation among individuals, both in terms of their susceptibility and tolerance.

Dermatitis due to skin contact with formaldehyde solutions and formaldehyde-containing resins is a well-recognized problem. Both primary skin irritation and allergic dermatitis have been reported.[6] Dermatitis may appear a few days following the commencement of work or may not appear for a number of years following exposure.[8]

In two separate studies, formaldehyde has induced a rare form of nasal cancer in rodents following repeated inhalation exposure.[9,10] Concern over the possible human carcinogenicity of formaldehyde has prompted several epidemiologic studies of workers exposed to formaldehyde. An association between formaldehyde exposure and cancer of the upper respiratory passages in humans has recently been reported.[11] In this proportionate mortality study of workers exposed to formaldehyde in the garment industry, a statistically significant excess in mortality from cancers of the buccal cavity and connective tissue were found. No cases of nasal cancer were observed, however. In a reanalysis of a National Cancer Institute study, "a statistically nonsignificant but suggestive increase for age-adjusted relative risk for buccal and pharyngeal cancer among employees with greater than 0.5 ppm average exposure in plants manufacturing formaldehyde resins" was found.[12]

In 1984, Ulsamer et al. reviewed 4 animal inhalation studies. No teratogenic effects were reported in these studies.[13] No birth defects were reported in a study which involved the application of formalin to the backs of

pregnant hampsters.[14] No data were found linking formaldehyde with teratogenic effects in humans. There was one report in which an increased incidence of menstrual disorders, and of complications of pregnancy and delivery, were reported among women workers exposed to formaldehyde at a textile factory in the USSR.[15] The relevance of these findings has been criticized, however, due to a lack of information regarding the suitability of the control group and potential confounding factors.[16]

In April 1981, NIOSH issued Current Intelligence Bulletin 34, "Formaldehyde: - Evidence of Carcinogenicity", DHHS (NIOSH) Publication No. 81-111.[17] In this bulletin, NIOSH recommends that formaldehyde be handled as a potential occupational carcinogen and that appropriate controls be used to reduce worker exposure to the lowest feasible level.[6] This recommendation was based primarily on a study in which nasal cancers developed in rats and mice following repeated inhalation exposures of approximately 15 ppm formaldehyde. In December, 1987, OSHA published an amended formaldehyde standard, 29 CFR 1910.1048. This standard reduced the PEL from 3 ppm to 1 ppm, as an 8-hour TWA.[18] In addition, a 15-minute short term exposure limit (STEL) was set at 2 ppm. ACGIH has given formaldehyde an A2 designation, indicating that ACGIH considers formaldehyde a suspected human carcinogen. The ACGIH TLV for formaldehyde is 1 ppm as an 8-hour TWA and 2 ppm as a 15-minute STEL.[19] ACGIH has recently proposed a ceiling limit of 0.3 ppm formaldehyde in their notice of intended changes for 1989-1990.[19] This value will be reconsidered for the adopted TLV list after 2 years.

C. Particulates

Airborne dust generated during garment manufacture consists of solid particles of fabric (lint), which may be suspended in air and inhaled. The current OSHA PEL for total nuisance dust (particulates not otherwise regulated) is 15 milligrams of dust per cubic meter of air (mg/m^3).[20] The ACGIH TLV for total nuisance dust is 10 mg/m^3.[19] These evaluation criteria were established to minimize mechanical irritation of the eyes, nose, throat and lungs. Because lint particles may contain free or bound formaldehyde, the nuisance dust evaluation criteria may not be appropriate.

D. Adverse Reproductive Outcomes

Rates of miscarriages, stillbirths, birth defects, and premature births were ascertained for current and former women Rockcastle employees. The rate of miscarriages in the general population is estimated to be from 10-25% depending upon which ascertainment method is used and at what stage the pregnancies are documented.[21] The rate of birth defects is between 1 and 10% depending on whether minor defects such as large birth marks are included.[22]

VI. RESULTS

A. Environmental

Results from the exposure monitoring for formaldehyde conducted during the initial survey are shown in Table 1. TWA formaldehyde levels ranged from trace (0.14 ppm) to 0.46 ppm in PBZ air samples, and from 0.32 ppm to 0.70 ppm in area air samples obtained in production departments. Although the samples

obtained in sewing areas 1 through 4 were collected as area samples, the results can be considered representative of personal exposures, as the sampling equipment was located within 2 feet of the operator and at breathing zone height. In addition, the formaldehyde levels in sewing areas 1 through 4 (in the middle of the plant where the majority of the workforce is located) ranged from 0.65 ppm to 0.70 ppm, showing little variation. Air samples collected in the front office and the conference room were considerably lower, 0.13 ppm and 0.28 ppm, respectively.

Formaldehyde air sampling data from the follow-up survey are shown in Table 2. Results from the three different sampling methods for formaldehyde (liquid impingers, solid sorbent tubes, and passive monitors) are shown along with the averaged data from the three methods. As can be seen from the averaged data, formaldehyde levels ranged from 0.19 ppm to 0.21 ppm in PBZ air samples, and from 0.18 ppm to 0.22 ppm in area air samples obtained in production departments. The area air sample collected in the conference room had a concentration of 0.11 ppm. In all cases, formaldehyde concentrations measured on the follow-up survey of January, 1988, were lower than on the initial survey of September, 1987. In addition, the formaldehyde concentrations showed much less variation among departments and job classifications on the follow-up survey. Formaldehyde concentrations in sewing areas 1 through 4 averaged 0.26 ppm (using only the impinger data), as compared with an average concentration of 0.68 ppm found in these same areas on the initial survey, using the same sampling method.

Although there was some variation among the formaldehyde results from the 3 different sampling and analytical methods, the data show distinct trends, with the impinger method giving the highest concentrations and the passive monitors giving the lowest concentrations. The sorbent tube results generally fell between the impinger and passive monitoring results. All air sampling results obtained from the two NIOSH surveys were below the current OSHA PEL and ACGIH TLV for formaldehyde of 1 ppm, as an 8-hour TWA. Latent formaldehyde levels in fabric samples obtained at this facility ranged from 124 micrograms of formaldehyde per gram of fabric (ug/gm) to 1430 ug/gm. Patches of the navy blue fabric which was being used during this survey had levels of 468 ug/gm and 280 ug/gm prior to being cured (steam pressed only) and levels of 124 ug/gm and 161 ug/gm, respectively, after being cured at 350°F for 15-minutes. Substantial reductions in latent formaldehyde were obtained on cured patches of fabric. This is in agreement with previous studies which have shown that post-cure fabrics generally release more formaldehyde than similar fabrics which have undergone the curing step before garment manufacture.[23]

The results of total dust sampling performed on both the initial and follow-up surveys are shown in Table 4. Total particulate concentrations ranged from 0.17 mg/m^3 to 2.12 mg/m^3 in PBZ air samples, and from 0.02 mg/m^3 to 0.42 mg/m^3 in area air samples obtained at several locations within the plant. The highest particulate concentrations were obtained on the turn and ticket operator (turns pants right side out using a vacuum machine) and the fabric cutter, at 2.12 mg/m^3 and 1.00 mg/m^3, respectively. Although these levels are well below the OSHA PEL of 15 mg/m^3 and ACGIH TLV of 10 mg/m^3, both as 8-hour TWAs, these evaluation criteria may not be entirely appropriate from a health standpoint, as formaldehyde may be present on the particulates.

An infrared spectrum of the acrylic polymer sprayed on the edges of fabrics to prevent ravelling matched that of a reference spectrum of ethyl acrylate homopolymer. Further analysis of the volatile components of this

product collected on a charcoal tube sample obtained in the headspace of a glue container showed the presence of acetone, isopropyl alcohol, ethyl acetate, t-butanol and ethyl propanoate, with minor amounts of ethanol and ethyl butanoate. Epichlorohydrin, which is used in the manufacture of this product, was not found in the bulk air sample.

A bulk air sample collected on a charcoal tube obtained near the two curing ovens showed low levels of acetone, isooctane, toluene, and perchloroethylene. The remaining organic vapor samples collected as full-shift air samples on the 2 oven operators, a steam press operator, and the glue sprayer, showed only 1,1,1-trichloroethane (which is present in a solvent and degreasing spray). The concentration of 1,1,1-trichloroethane in these samples was quite low (less than 0.3 ppm), with all values falling well below the current OSHA PEL for 1,1,1,-trichloroethane of 350 ppm as an 8-hour TWA. The NIOSH REL for 1,1,1-trichloroethane is 350 ppm as a 15-minute ceiling level. Epichlorohydrin, ethyl acetate, t-butanol, isopropanol, acetone, and ethyl propanoate were not detected on any of the PBZ charcoal tube air samples, to a limit of detection of 5 ug per sample. This corresponds with levels of epichlorohydrin, ethyl acetate and t-butanol of less than 0.1 ppm.

On the initial survey (September, 1987), ambient temperatures ranged from 71°F to 83°F, with the highest temperatures recorded near the steam presses and curing ovens. The relative humidity within the plant ranged from 48% to 68%, with the highest value recorded in the glue room, which was also the site of the lowest air temperature of 71°F. During the January survey, air temperatures ranged from 71°F to 82°F, showing little difference from the initial survey. Again, the highest temperatures were recorded near the presses and the ovens, as expected. The relative humidity was considerably lower, ranging from 14% by the presses and ovens, to 36% in the sewing areas.

B. Medical

Of the 191 current employees, 188 responded to the questionnaire, for a response rate of 98%. Only 48 of the 262 former employees returned the questionnaire, for a former employee response rate of only 18%. Of the current employees who responded to the questionnaire, 20 were male (11%) and of the former employees, 3 (6%) were male.

Reproductive

Among the women respondents (current and former), there were 386 pregnancies, of which 12 were current pregnancies and 2 were ectopic pregnancies. These 14 have been excluded because the outcome cannot be determined (ectopic pregnancies are excluded because there is no way to determine if a normal pregnancy would have occurred had the egg implanted in the uterus). Additionally, one woman who had been pregnant 8 times and who had had 6 miscarriages was excluded because multiple miscarriages are more likely to be due to genetic or anatomic causes rather than to external causes, such as occupational exposures. This individual had 4 of her 6 miscarriages while she was not working and then 2 additional miscarriages while at Rockcastle. She was also one of the 12 currently pregnant employees.

The remaining 365 pregnancies were divided into three catagories based on the woman's reported employment status at the time of her pregnancy: 1) pregnancies that occurred while the woman was employed at Rockcastle, 2) pregnancies that occurred while the woman was working someplace other than Rockcastle, and 3) pregnancies that occurred while the woman was not working outside the home. These three groups were chosen in order to separately examine the effects on pregnancy of working anywhere outside of the home, from the effects of working specifically at Rockcastle. Rates of miscarriages, birth defects, stillbirths and premature births were calculated for each of the three employment status groups. There were 4 sets of twins; the three sets which resulted in normal births were classified as a single pregnancy whose outcome was a normal birth, and the one set where there was one stillbirth and one normal birth was classified as a stillbirth. Since there was such a poor response rate for the questionnaire sent to former employees, these rates were calculated both for the present workforce and the present and former workforce (Table 5).

The rates of miscarriages in those working at Rockcastle and those working elsewhere were 14% and 13%, both of which are similar to the nationally reported average rates. The rate of miscarriages in the group at home was only 5%, which is much lower than expected in the general population and significantly lower than in those who worked outside the home ($p=.002$).

The rates of other adverse outcomes combined, including birth defects, still births and premature births, were then examined. Among those working at Rockcastle during their pregnancy, the rate was 42%, among those working elsewhere it was 5%, and among those at home it was 6%. Since the rates among those at home and those who worked elsewhere were similar, these two groups were combined. The relative risk of having a stillbirth, a premature birth, or a child with a birth defect in those who worked at Rockcastle during their pregnancy, compared to those who did not work at Rockcastle was 6.9 (95% confidence intervals 3.6, 13.1, $p<.001$ Fisher's exact test).

When only current workers were evaluated, the rate of miscarriages in those who were working at Rockcastle during their pregnancy was 21%, in those working elsewhere it was 15%, and in those at home it was 5%. There was no statistically significant difference between those working at Rockcastle and those working elsewhere. The rates of birth defects, stillbirths, and premature births in current employees only were examined in the same manner as above. The rate of these adverse outcomes in women who worked at Rockcastle during their pregnancy was 33%, 5% in those who worked elsewhere and 7% in those who were at home. As before, since the rates in those at home and those working elsewhere were similar, they were combined. The relative risk of having a stillbirth, a premature birth, or a child with a birth defect among current workers who worked at Rockcastle during their pregnancy, compared to current workers who did not work at Rockcastle, was 5.3 (95% confidence intervals 2.2, 12.5, $p=.003$ Fisher's exact test).

No medical records regarding the birth defects were reviewed, but according to the description of these birth defects by the mothers, 5 of the 7 that occurred in women who became pregnant while at Rockcastle could be classified as major. A discussion with a geneticist from the University of Kentucky who staffs a satellite clinic in the Rockcastle area confirmed that there were several major birth defects during the time period in question, 1985-1986.

A number of other factors can lead to adverse outcomes of pregnancies, including smoking, alcohol use, use of medications, and the presence of some diseases, such as diabetes. There was no significant difference in any of these other factors between those who worked at Rockcastle while they were pregnant and those who did not.

An evaluation was made of where the individuals worked who had an adverse outcome while working at Rockcastle. There was no difference in the distribution of jobs between those who had a normal pregnancy while working at Rockcastle and those who had an adverse outcome while working at Rockcastle (Table 6). The rate in sewing, 50%, where most of the adverse outcomes occurred, was not substantially greater than the overall rate of 42%.

An evaluation was made to determine if there was a concentration of adverse reproductive outcomes during any time period. Figure 1 shows a graph of the occurrence of these birth defects, stillbirths, and premature births by the year of occurrence. There was a sharp increase in these adverse outcomes in 1986.

Musculoskeletal and Other Health Complaints

The results for the questions concerning musculoskeletal complaints and other health complaints were tabulated for current employees only. On the musculoskeletal complaints, workers were asked to rate each complaint on a scale of 1 to 5 (1=never and 5=always). A positive response was defined as an answer of 4 or 5. The proportions of positive responses were calculated and can be found in Table 7. Most of the complaints involved the neck, shoulder, back and legs as compared to the arms and hands.

For the questions concerning irritation, workers were asked to mark the frequency of their symptoms (1=never to 4=most days). A positive response was a symptom that occurred on most days. These results can be found in Table 8. The most common symptoms reported included those associated with upper respiratory tract irritation, eye irritation, headaches and skin irritation.

VII. DISCUSSION

A reduction in formaldehyde levels in PBZ and area air samples was noted on the follow-up survey. This survey was performed after several ventilation changes had been instituted, including an increase in the amount of dilution ventilation and installation of local exhaust ventilation above fly press and steam press tables. Formaldehyde concentrations in sewing areas 1 through 4, where the majority of the workforce is located, averaged 0.68 ppm on the initial survey and 0.26 ppm on the follow-up survey. In addition, the exposure range was much narrower on the follow-up survey, suggesting that the ventilation changes may have improved air circulation and mixing within the plant. It should be noted, however, that these formaldehyde measurements were made at one point in time and may not reflect seasonal variations. Factors which may affect formaldehyde levels include ambient temperature and humidity, volume of stored fabric, and changes in resin finishing formulations.

Although the formaldehyde levels measured during this survey were all below the OSHA PEL and ACGIH TLV of 1 ppm, as an 8-hour TWA, efforts to further reduce formaldehyde levels should continue in an effort to achieve the lowest feasible level, as formaldehyde is considered a potential human carcinogen. A continued reduction in formaldehyde levels will also help minimize complaints of eye, nose, and throat irritation, which can be experienced at very low levels.

As previously noted, results from the side-by-side Bacharach Airscan* Formaldehyde Exposure Monitors gave somewhat lower results than the other two established air sampling methods for formaldehyde. There was some difficulty in determining the actual formaldehdye concentration obtained with the monitors, due to uneven stain development. These monitors utilize the principle of nucleation and crystal growth, whereby formaldehdye is reacted within the monitor, forming a crystal seed that grows with the addition of a developer solution. The difficulty in

assessing the length of stain (for direct reading of formaldehyde concentration) was conveyed to the firm which markets this product. This resulted in development of a new film having a thicker coating.

While most latent formaldehyde levels on fabric samples collected at this plant were below 500 ug/gm, one sample resulted in a formaldehyde release of 1430 ug/gm, considerably higher than the level of 1000 ug/gm specified on the resin finisher's material safety data sheet.

Jobs which resulted in the greatest particulate exposure were the cutting operation (1.00 mg/m^3) and turn and ticket operation (2.12 mg/m^3). These particulate concentrations are below the evaluation criterion for total nuisance dust. However, this dust may present an additional source of formaldehyde exposure and is therefore not simply a nuisance dust. There is a concern that this additional formaldehyde source may contribute to symptoms of imitation as well. NIOSH is presently evaluating a method for measuring low levels of formaldehdye physically adsorbed onto the surface of particulates, or chemically bound in the particulate. Further research is needed in assessing potential exposures and health effects from this exposure source.

Levels of organic vapors found on PBZ and area air samples (using charcoal tubes) were very low. The only substance present above the limit of detection on PBZ air samples obtained on the glue sprayer, the two oven operators, and a press operator, was 1,1,1-trichloroethane. In all cases, this substance was present at levels more than 1000 times below the OSHA PEL. Therefore, inhalation of this substance would not be expected to result in adverse health affects.

The results of the questionnaire show that there was a statistically significant elevated rate of birth defects, stillbirths, and premature births in women who were pregnant while working at Rockcastle compared with women who were pregnant while working elsewhere and with women pregnant not working outside the home. There was a clustering of these adverse outcomes in 1986. Most of the women who work at Rockcastle are in the sewing areas, and there was no significant difference in work area between those who had adverse pregnancy outcomes and the workforce as a whole.

Former employees were surveyed in order to determine if women who left employment had similar problems to those still working. Unfortunately, the response rate from former employees was too small to assess this. The major bias presented by excluding former workers is that women who had normal pregnancies may have stopped working to care for their children. When there is a low response rate from former employees, the concern is that those who had a problem are more likely to have responded. Therefore, it is difficult to determine how accurate this elevated rate is without knowing the outcomes of pregnancies among the former workers who did not respond to the questionnaire.

An excess of birth defects and other adverse pregnancy outcomes among a small group of workers is often called a "cluster". It is difficult to look at a single group of workers and determine whether an elevated rate is due to an exposure or to coincidence alone. Once a statistical association has been demonstrated, the findings need to be compared to other similar studies. We do not know of any reports of similar adverse pregnancy outcomes in women exposed to formaldehyde. The concentrations of formaldehyde and other organic vapors are probably lower now than they had been in the past, as a result of continuing improvements in ventilation and the use of resins that release less formaldehyde. However, it is not possible to determine what past exposures were, as industrial hygiene sampling data are not available. The glue and cleaning fluids used at this facility had reportedly not been changed since the plant's inception (with the exception of the cleaning fluid that was changed after the initial NIOSH investigation).

A number of health complaints were expressed by employees. Because most of the symptoms occur to most people at some time, for the purposes of our survey a symptom was considered present only if it was reported to be frequent ("almost always" or "always" for musculoskeletal complaints, and "on most days" for the other symptoms).

Approximately one-third of the workers reported pain in their shoulders, neck, back, and legs. Although not the primary focus of our evaluation, we observed awkward positions among the workers. Detailed ergonomic evaluations in other garment manufacturing facilities have found that these types of awkward positions can result in complaints and can lead to a number of medical conditions such as tendonitis, bursitis, chronic back strain, and varicose veins.[24]

Other health complaints frequently reported were irritation of the eyes and nose, as well as headaches and skin rash. Exposures to formaldehyde even in low concentrations can lead to these types of complaints.[8]

VIII. RECOMMENDATIONS

Since the initial NIOSH investigation, many ventilation and workpractice changes were made, some of which had been recommended by the NIOSH investigators. Further changes have been made since the second NIOSH visit, including the installation of local exhaust ventilation at the point of steam generation at the fly press stations. These changes have improved working conditions at this plant. The following additional recommendations are offered to further reduce the formaldehyde exposure potential, to minimize potential ergonomic hazards, and to monitor future reproductive outcomes of Rockcastle Manufacturing employees.

1. Rockcastle Manufacturing should continue to work with the textile finishing company which supplies the post-cure fabrics to ensure utilization of resin systems offering lower formaldehyde release. Rockcastle should also request that the finisher supply formaldehyde release data on random fabric samples as a quality control measure. In addition, the possibility of using pre-cure fabrics (which may have lower formaldehyde release) should be explored.
2. Periodic exposure monitoring for formaldehyde should be performed, taking into consideration potential seasonal variations in formaldehyde levels. Exposure monitoring should also be conducted after ventilation changes are made, when new resin treatments are used, and following other work practice changes which may affect airborne formaldehyde levels.

3. The questionnaire data indicated a large number of complaints of the shoulder, neck, back, and legs. To reduce the potential for development of cumulative trauma disorders, an ergonomic evaluation should be performed at this facility. This is particularly important, in light of planned expansion and renovation activities (installation of new curing ovens, elimination of glue spraying operation, increasing the size of the plant, etc.).

4. Since this evaluation found a cluster of adverse reproductive outcomes, a surveillance system should be established to determine if this trend continues. Clusters can be due to a number of factors and the continued surveillance of pregnancies should differentiate an ongoing problem from one due to other factors, including chance.

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XI. DISTRIBUTION AND AVAILABILITY OF REPORT

Copies of this report are temporarily available upon request from NIOSH, Hazard Evaluations and Technical Assistance Branch, 4676 Columbia Parkway, Cincinnati, Ohio 45226. After 90 days, the report will be available through the National Technical Information Service (NTIS), 5285 Port Royal, Springfield, Virginia 22161. Information regarding its availability through NTIS can be obtained from NIOSH Publications Office at the Cincinnati address. Copies of this report have been sent to:

1. Rockcastle Manufacturing
2. Cintas Corporation
3. Confidential Requestors
4. OSHA, Region

For the purpose of informing affected employees, copies of this report shall be posted by the employer in a prominent place accessible to the employees for a period of 30 calendar days.

Table 1
Formaldehyde Exposure Data, Rockcastle Manufacturing, Mount Vernon, Kentucky
HETA 87-349, September 9, 1987

Sample Description	Sampling Time (minutes)	Sample Volume (liters)	Formaldehyde Concentration TWA[b] (ppm)[a]	(ppm)
Personal Breathing Zone Air Samples[c]				
oven operator #1	516	25.0	(0.29)	
oven operator #2	511	26.7	(0.30)	
steam press operator	509	27.6	0.38	
glue sprayer	442	19.0	(0.14)	
fly press operator	471	24.6	0.46	
Area Air Samples[d]				
conference room	339	64.4	0.28	
fabric storage area	200	100.0	0.34	
	202	101.0	0.46	0.40
boxing department	197	98.5	0.41	
	199	99.5	0.48	0.45
cutting table	197	98.5	0.50	
	198	99.0	0.60	0.55
area 1 - welts	193	96.5	0.60	
	198	99.0	0.79	0.70
area 2 - pocket set	194	97.0	0.60	
	199	99.5	0.77	0.69
area 3 - waist band set	194	97.0	0.60	
	198	99.0	0.78	0.69
area 4 - belt loop	194	97.0	0.57	
	198	99.0	0.73	0.65
Press area	190	95.0	0.49	
	204	102.0	0.67	0.58
Press 141	190	95.0	0.47	
	202	101.0	0.69	0.58
Press 157	190	95.0	0.48	
	193	96.5	0.71	0.60
outside oven (pant	190	95.0	0.33	
rack cooling area)	197	98.5	0.51	0.42
glue room (shelf)	186	93.0	0.32	
front office (by copier)	189	94.5	0.13	
outside oven (pant rack cooling area)	15	15.0	0.39	
	15	15.0	0.41	
NIOSH Recommended Exposure limit (REL)		Lowest Feasible Level		
OSHA Permissible Exposure limit (PEL)		8-hr TWA	1.0	
		15-min STEL	2.0	
ACGIH Threshold Limit Value (TLV)		8-hr TWA	1.0	
		15-min STEL	2.0	

[a] Formaldehyde concentration is expressed in parts per million (ppm). Values in parentheses indicate formaldehyde concentrations between the limit of detection (LOD) and limit of quantitation (LOQ).

[b] TWA refers to the time-weighted average concentration over the entire sampling period.

[c] Personal breathing zone air samples were collected and analyzed according to NIOSH Method 2502 (solid sorbent tube method). The LOD and LOQ were 4 and 12 micrograms per sample, respectively.

[d] Area air samples were collected and analyzed according to NIOSH Method 3500 (impinger method). The LOD and LOQ were 0.4 and 1.3 micrograms per sample, respectively.

Table 2
Comparison of Formaldehyde Air Sampling Results
Using Solid Sorbent Tubes, Liquid Impingers
and Passive Monitors
Rockcastle Manufacturing
Mount Vernon, Kentucky
HETA 87-349
January 13, 1988

FORMALDEHYDE CONCENTRATION (ppm)[a]

Sample Location/ or Job	Sampling Time (minutes)	Sorbent Tubes A	Sorbent Tubes B	Liquid Impinger	Passive Monitor	Average
Cutter	436	PF[b]	0.20	0.20	0.16	0.19
Press Operator	438	0.22	0.15	0.25	0.15	0.19
Fly Press Operator	423	0.20	0.21	0.23	0.18	0.21
Area 1 - Hip Pocket	503	0.18	0.15	0.23	0.15	0.18
Area 2 - Front Pocket	501	0.15	0.15	0.25	0.16	0.18
Area 3 - Waist Band Set	442	0.19	0.22	0.28	0.15	0.21
Area 4 - Belt Loop	443	0.18	0.18	0.28	0.16	0.20
Press 139	480	0.18	0.21	0.25	0.22	0.22
Outside the Curing Ovens	494	0.20	0.16	0.31	0.11	0.20
Conference Room	489	0.12	0.13	0.19	ND (<0.1)	0.11

NIOSH Recommended Exposure Limit (REL)	Lowest Feasible Limit	
OSHA Permissible Exposure Limit (PEL)		
	8-hour TWA	1.0
	15-min STEL	2.0
ACGIH Threshold Limit Value (TLV)		
	8-hour TWA	1.0
	15-min STEL	2.0

[a]Formaldehyde concentrations are expressed as time-weighted averages (TWA) over the sampling period in parts per million (ppm). Side-by-side air samples were collected using three different methods: (1) solid sorbent tube method (NIOSH 2502), (2) liquid impinger method (NIOSH 3500), and a passive monitoring method using Bacharach* AirScan Formaldehyde Exposure Monitors.
ND = none detected.
[b]PF = Pump failure.

Table 3

Latent Formaldehyde Levels on Resin-Treated Fabrics

Rockcastle Manufacturing
Mount Vernon, Kentucky
HETA 87-349

September 9, 1987

Fabric Description	Latent Formaldehyde ug/gm[a]
navy blue - stored at the plant for less than one month:	
steam pressed only	468
steam pressed and cured @ 350 F for 15-min.	124 (73.5% reduction)
navy blue - stored at the plant for > 60 days:	
steam pressed only	280
steam pressed and cured @ 350 F for 15-min.	161 (42.5% reduction)
emerald green - length of storage unknown	
not pressed or cured	312
bluish black - length of storage unknown	
not pressed or cured	244
brown - length of storage unknown	
not pressed or cured	219
royal blue - length of storage unknown	
not pressed or cured	1430
dark green - length of storage unknown	
not pressed or cured	382
white - length of storage unknown	
not pressed or cured	163

[a] Latent formaldehyde levels are expressed as micrograms of formaldehyde per gram of fabric (ug/g).

Table 4
Total Particulate Exposure Data
Rockcastle Manufacturing
Mount Vernon, Kentucky
HETA 87-349

Sample Description	Sample Type[a]	Sampling Time (minutes)	Sample Volume (liters)	Total Particulate Concentration (mg/m3)[b]
September 9, 1987				
Spreader	PBZ	387	580	0.17
Cutter	PBZ	392	588	1.00
Maintenance (sweeping)	PBZ	385	578	0.29
Turn & Ticket Operator	PBZ	483	725	2.12
Welts (by machine)	A	474	711	0.42
January 13, 1988				
Turn & Ticket Machine	A	422	844	0.12
Area 1	A	413	826	0.13
Area 3	A	413	826	0.13
Cutting Table	A	426	852	0.02
NIOSH Recommended Exposure Limit (REL)				none established
OSHA Permissible Exposure Limit (PEL) (Nuisance Dust)				15
ACGIH Threshold Limit Value (TLV) (Nuisance Dust)				10

[a] PBZ = personal breathing zone air sample; A = area air sample.
[b] Total particulate concentration is expressed in milligrams of dust per cubic meter of air (mg/m^3) as a time-weighted average over the sampling period.

Table 5
Proportions of Adverse Reproductive Outcomes

Rockcastle Manufacturing
Mount Vernon, Kentucky
HETA 87-349

January, 1988

Current and Former Workers (365 total pregnancies)

Employment Status during pregnancy	Miscarriages	Birth Defects*	Stillbirths*	Premature*
Rockcastle (28 pregnancies)	14%	25%	4%	13%
Working but Not at Rockcastle (91 pregnancies)	13%	4%	0	1%
Not Working (246 pregnancies)	5%	2%	2%	3%

Current Workers Only (296 total pregnancies)

Employment Status during pregnancy	Miscarriages	Birth Defects*	Stillbirths*	Premature*
Rockcastle (19 pregnancies)	21%	13%	7%	13%
Working but Not at Rockcastle (71 pregnancies)	15%	3%	0	2%
Not Working (206 pregnancies)	5%	2%	2%	4%

* These proportions are based on the total number of pregnancies that did not end in a miscarriage

Table 6

Rate of Adverse Outcomes
While Women Were Employed At Rockcastle
By Work Area

Rockcastle Manufacturing
Mount Vernon, Kentucky
HETA 87-349

January, 1988

	All Pregnancies		Pregnancies resulting in Birth defects, Stillbirths, Or Premature births	
	Number	%	Number	%
Pressing	3	25%	0	0% 25%
Sewing	16	67%	8	50% 67%
Inspecting	2	8%	1	50% 8%
Fabric Cutting	1	4%	1	100%

Table 7

Rates of Musculoskeletal Complaints
Among Current Rockcastle Employees

Rockcastle Manufacturing
Mount Vernon, Kentucky
HETA 87-349

January, 1988

Complaint	Proportion Who Reported Symptoms
Shoulder Pain	38%
Neck Pain	35%
Lower Back Pain	35%
Upper Back Pain	34%
Leg Pain	33%
Forearm Pain	19%
Hand Numbness	17%
Elbow Pain	15%

Table 8

Rates of Imitation Complaints
Among Current Rockcastle Employees

Rockcastle Manufacturing
Mount Vernon, Kentucky
HETA 87-349

January, 1988

Complaint	Proportion Who Reported Symptoms
Frequent Sneezing	28%
Burning Eyes	27%
Runny Nose	24%
Skin rash	24%
Burning Nose	23%
Headache	22%
Lightheadedness	12%
Sore Throat	10%
Ringing in Ears	9%
Nausea	5%
Stomach Cramps	3%
Fainting	1%
Vomiting	<1%

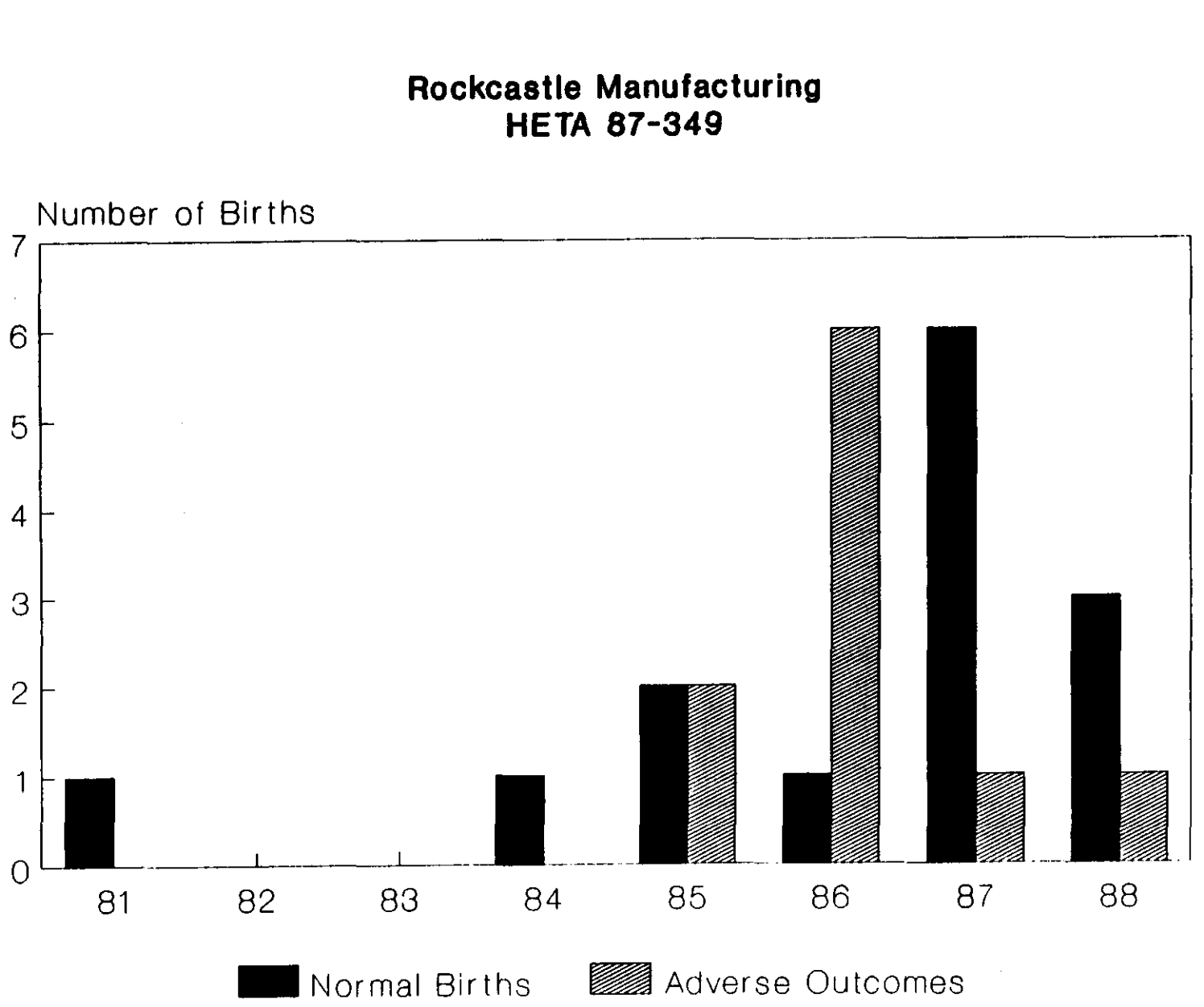

Figure 1--Pregnancy outcomes for Rockcastle Manufacturing employees from 1981-1988.